Calibration blocks for gamma-ray survey instrumentation

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CALIBRATION BLOCKS FOR GAMMA-RAY SURVEY INSTRUMENTATION

Summary report prepared for
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1. INTRODUCTION

Over the past several years the International Atomic Energy Agency and the OECD Nuclear Energy Agency have been promoting the use of standard units for the reporting of radioactivity surveys for uranium exploration. The recommended total-count unit is that of the "Ur" which produces the same instrument response as one part per million of uranium in radioactive equilibrium (1 ppm eU). There are several advantages of expressing the radioactivity of the ground in Ur's: The use of 1 ppm eU as the basic reference provides an immediate first-hand impression of apparent ore grades; the grade of thorium-free uranium ore is measured directly apart from a possible disequilibrium factor; and data recorded with different instruments may be compared without any difficulty.

Nobody can, of course, report their measurements in Ur's without having access to a calibration source of known radioactive concentration. In fact, the future success of standardized radiometric reporting depends on the actual presence of calibration facilities in all countries with a uranium exploration programme. It would be good if the calibration sources themselves could be standardized. If everybody would agree to accept a few basic source modules, the installment of a calibration facility might simply be a question of ordering the proper modules from a central supply. In this way instrument calibration could be made inexpensive and easily available.

The calibration blocks described here have been developed in collaboration with a Danish construction company. They are designed for calibration experiments with surface instrumentation and logging equipment and are presently being tested at Risø, Denmark, and at the nuclear research centre "Demokritos" in Athens, Greece. It is believed that blocks like these would be the answer to the calibration demand associated with ground follow-up and borehole logging in many countries.

2. BLOCK DESIGNS

The two kinds of proposed source modules or blocks are shown in Fig. 1. An A-block is intended for the calibration of portable counters and spectrometers and consists of a 145 x 50 cm concrete well ring filled with radioactively loaded concrete mixture. A B-block is constructed similarly using a well ring of the double length. Such a block is penetrated by a 82 mm hole from top to bottom and is the module for building a borehole calibration model. The radioactive material contained in the blocks is low-grade uranium ore with 400 ppm U and 850 ppm Th. It derives from the Kvanefjeld deposit in South Greenland and is available in great quantities at Risø. The ore is formed by a peralkaline nepheline syenite magma which is not leached when mixed with cement and water.

The test series of blocks was made from three mixture types of different radioactive loading, see Table 1. Type H ("high") contains 4.3 times as much ore as type M ("medium"), and type L ("low") represents concrete without any ore added. The concentrations of K, eU, and Th were assayed by gamma-ray spectrometry using potassium salts and reference materials from the US New Brunswick Laboratory as counting standards. Concentrations in Ur's were assigned to the mixtures from the conversions

1% K = 0.80 Ur [a)]
1 ppm eU = 1.00 Ur [b)]
1 ppm Th = 0.36 Ur [a)]

3. CONSTRUCTION OF CALIBRATION FACILITIES

A calibration facility consisting of 3 A-blocks and 4 B-blocks was established at Risø, and a similar facility is under con-

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a) Determined from calibration experiments with portable counters at pad facility at Risø National Laboratory.

b) Definition.

struction at the "Demokritos" centre in Athens. Blocks AH-1, AL-2, and AM-3 at Risø are placed in pits with their calibration faces in flush with the surrounding terrain. A borehole calibration model was constructed by stacking blocks BH-1, BL-2, BM-3, and BL-4 on top of each other. This 4 m high model is equipped with a rail at the top and can be ascended by an attached ladder. In Athens a borehole model will be constructed by lowering the B-blocks into a pit, so that logging calibrations can be made at ground level.

Table 1. Mixture types for calibration blocks with assayed radioactive concentrations.

Mixture type	%K	ppm eU	ppm Th	UR's
H	2.0	346	706	602
M	0.8	80	164	140
L	0.4	1.0	2.4	2.2

4. CALIBRATION PROCEDURES

The calibration of a portable counter on blocks AH-1, AL-2, and AM-3 is illustrated in Fig. 2. Recorded count rates plotted against the assigned radioactive concentrations in Ur's furnish a straight line whose slope gives the calibration factor for converting field readings into Ur's. A gamma-ray logging probe may be calibrated in the same way in a borehole model which also provides the logging response to the contact between two formations.

In order to determine the U and Th window sensitivities of portable spectrometers or spectral logging equipment, it is necessary to make a separate assay of the two stripping ratios, α and a. These are defined by the stripping equations

$$n_T' = (n_T - a n_U)/(1-a\alpha)$$

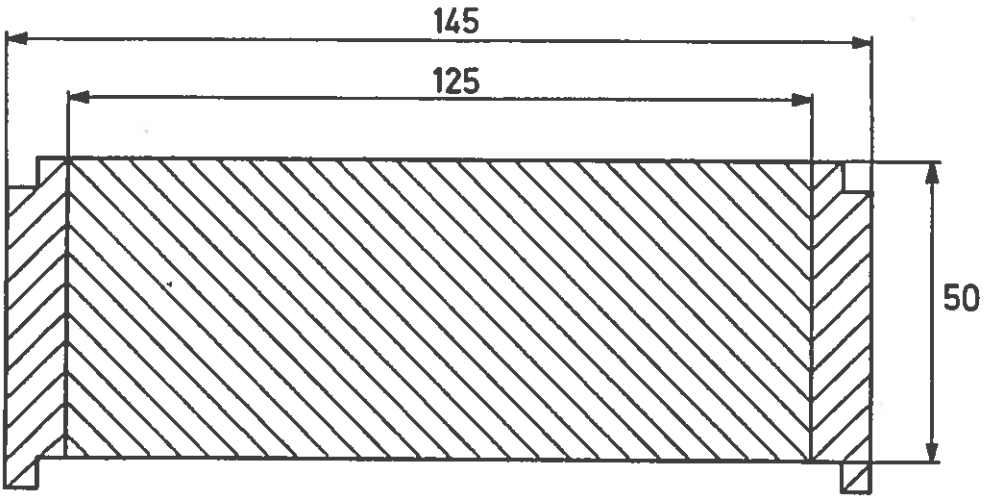
$$n_U' = (n_U - \alpha n_T)/(1-a\alpha),$$

where n_T and n_U are the recorded count rates in the Th and U energy windows. Determination of stripping ratios may be performed by irradiating the detector probe with small samples of pure uranium and thorium ores. A plot of the stripped count rates, n_T' and n_U', against the block concentrations of Th and eU then provides the two desired window sensitivities. It should be noted that the blocks contain insignificant potassium concentrations. They are consequently not suited for the determination of K window sensitivities.

5. CONCLUSION

The blocks described appear to be a solution to the instrument calibration problem associated with gross-count and spectral measurements for uranium exploration at the surface and in boreholes. Radioactive material for the manufacture of a large number of blocks is on stock, and a set of blocks might easily be shipped to any required destination. It is estimated that a complete set of A- and B-blocks could be supplied at a cost of approximately US$ 1300 plus shipping costs.

A - BLOCK



B - BLOCK

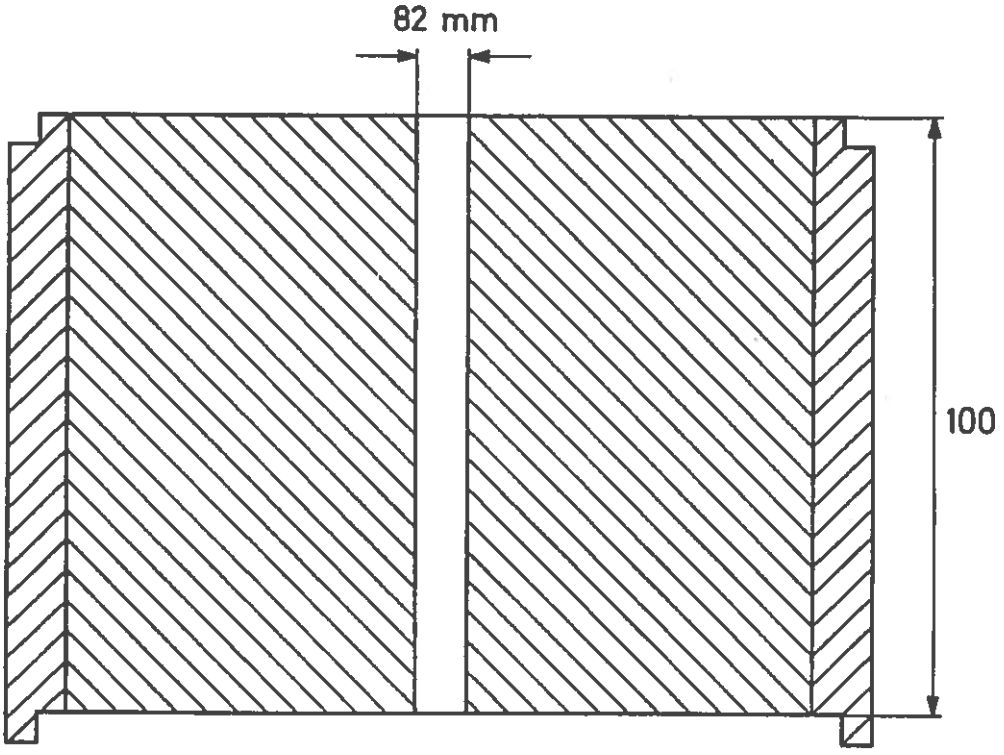


Fig. 1. Block designs based on radioactive concrete mixture poured into standard well rings.

Block	Ur value	Recorded cps with McPhar TC33-A scintillometer
AL-2	2	160
AM-3	140	890
AH-1	602	3480

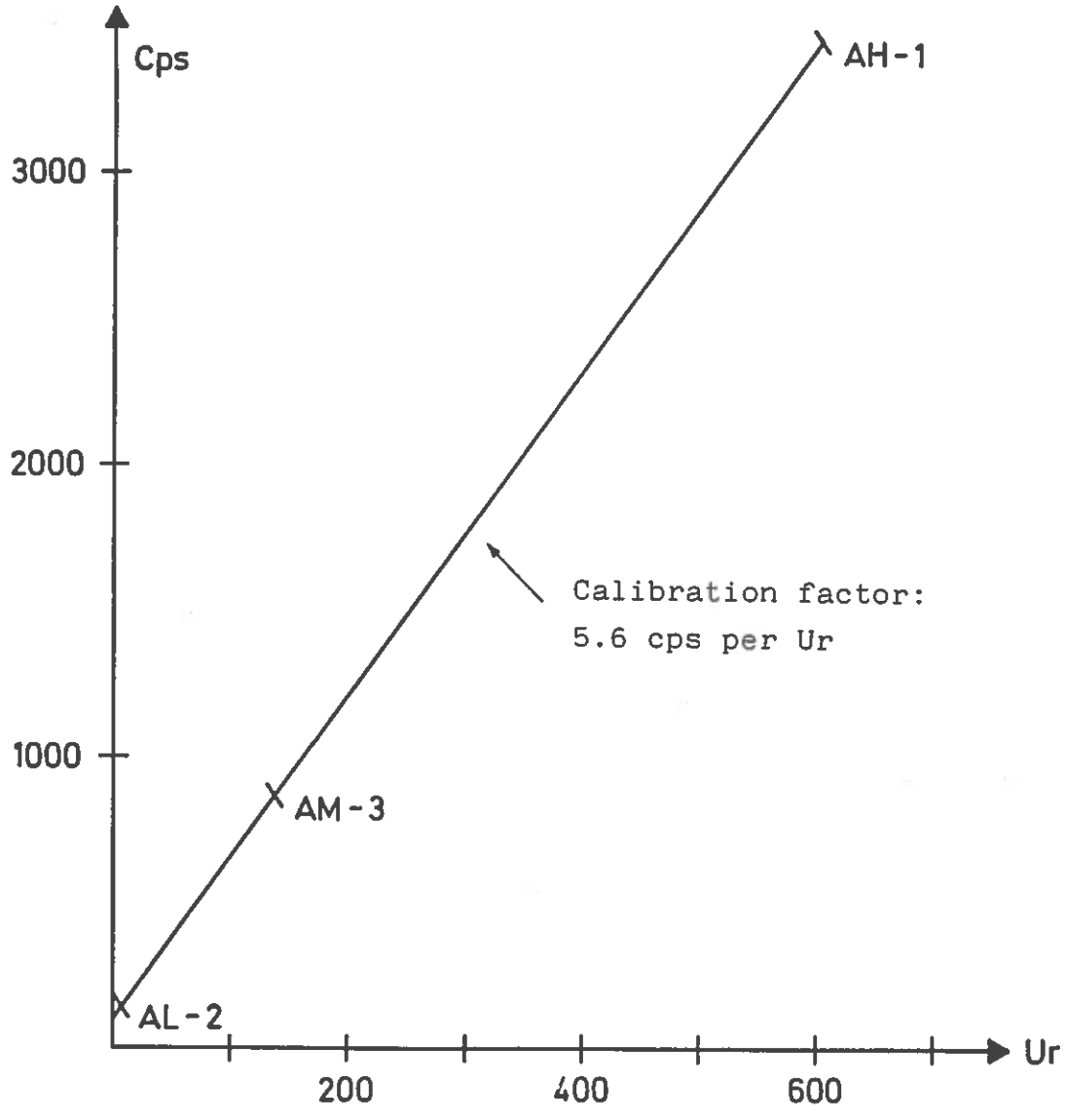


Fig. 2. Calibration line for McPhar TC33-A scintillometer.